CLAIMS

1. A surface acoustic wave device comprising:

a piezoelectric substrate made of $LiNbO_3$ having an electromechanical coupling coefficient whose square (k^2) is 0.025 or more;

at least one electrode that is made of a metal whose density is higher than that of Al or an alloy mainly containing the metal or that is composed of laminated films made of a metal whose density is higher than that of Al or an alloy mainly containing the metal and another metal, the electrode lying on the piezoelectric substrate;

a first insulating layer lying in a region other than a region where said at least one electrode lies, the thickness of the first insulating layer being almost equal to that of the electrode; and

a second insulating layer covering the electrode and the first insulating layer,

wherein the density of the electrode is more than 1.5 times higher than that of the first insulating layer.

2. A surface acoustic wave device comprising:

a piezoelectric substrate made of $LiNbO_3$;

at least one electrode lying on the piezoelectric substrate;

a protective metal film made of a metal or alloy that is more corrosion-resistant than a metal or alloy contained in the electrode, the protective metal film lying on the electrode;

a first insulating layer lying in a region other than a region where said at least one electrode lies, the thickness of the first insulating layer being almost equal to the total thickness of the electrode and the protective metal film; and

a second insulating layer covering the protective metal film and the first insulating layer.

3. The surface acoustic wave device according to Claim 2, wherein an average density of an entire laminated structure including the electrode and the protective metal film is more than 1.5 times higher than the density of the first insulating layer.

4. The surface acoustic wave device according to any one of Claims 1 to 3, wherein the first and second insulating layers are made of SiO_2.

5. The surface acoustic wave device according to any one of Claims 1 to 4, wherein reflection of surface acoustic waves is used in the surface acoustic wave device.

6. The surface acoustic wave device according to any one of Claims 1 to 5, wherein the height of a convex portion on a surface of the second insulating layer is 0.03λ or less when the wavelength of a surface acoustic wave is λ.

7. The surface acoustic wave device according to any one of Claims 1 to 5, wherein the height of a convex portion on the second insulating layer is 1/2 or less of the thickness of the electrode.

8. The surface acoustic wave device according to Claim 7, wherein the height of the convex portion on the second insulating layer is 1/3 or less of the thickness of the electrode.

9. The surface acoustic wave device according to any one of Claims 1 to 8, wherein the electrode mainly contains a metal heavier than Al.

10. The surface acoustic wave device according to Claim 9, wherein the electrode mainly contains a metal selected from a group consisting

of Au, Pt, Cu, Ta, W, Ag, Ni, Mo, NiCr, Cr, and Ti.

11. The surface acoustic wave device according to Claim 10, wherein the electrode is made of Au or Pt and the thickness thereof is in the range of 0.0017λ to 0.06λ when the wavelength of a surface acoustic wave is λ.

12. The surface acoustic wave device according to Claim 10, wherein the electrode mainly contains a metal selected from a group consisting of Au, Ag, Ni, Mo, Zn, Cu, Pt, Ta, W, Cr, and Ti, and wherein the thickness of the electrode is in the range shown in the following Table 1 when the wavelength of a surface acoustic wave is λ.

[Table 1]

Au	0.0017 λ ～ 0.06 λ
Pt	0.0017 λ ～ 0.06 λ
Ag	0.0035 λ ～ 0.10 λ
Ta	0.0025 λ ～ 0.064 λ
W	0.0035 λ ～ 0.06 λ
Cu	0.0058 λ ～ 0.11 λ
Ni	0.012 λ ～ 0.12 λ
Cr	0.012 λ ～ 0.12 λ
Ti	0.012 λ ～ 0.12 λ
Mo	0.012 λ ～ 0.12 λ
Zn	0.012 λ ～ 0.12 λ

13. The surface acoustic wave device according to any one of Claims 1 to 12, wherein the thickness of the second insulating layer is in the range of 0.15λ to 0.4λ when the wavelength of a surface acoustic wave is λ.

14. The surface acoustic wave device according to Claim 13, wherein the thickness of the second insulating layer is in the range of 0.2λ to 0.3λ when the wavelength of a surface acoustic wave is λ.

15. The surface acoustic wave device according to any one of Claims

1 to 14, wherein Euler angles of the piezoelectric substrate made of $LiNbO_3$ are in any of the ranges shown in the following Table 2.

[Table 2]

Euler angles
(0±5, 62～167, 0±10)
(0±5, 87～158, 20±10)
(0±5, 112～165, 80±10)
(0±5, 107～167, 100±10)
(10±5, 110～162, 80±10)
(10±5, 69～108, 100±10)
(10±5, 72～140, 160±10)
(20±5, 99～121, 160±10)
(30±5, 67～113, 0±10)
(30±5, 27～125, 140±10)
(30±5, 67～103, 160±10)

16. The surface acoustic wave device according to Claim 15, wherein Euler angles of the piezoelectric substrate made of $LiNbO_3$ are in any of the ranges shown in the following Table 3.

[Table 3]

$k_R^2 \leq 0.01$
(0±5, 80～160, 0±10)
(0±5, 100～142, 0±10)
(0±5, 112～165, 80±10)
(0±5, 107～167, 100±10)
(10±5, 123～158, 80±10)
(10±5, 74～90, 100±10)
(10±5, 87～128, 160±10)
(20±5, 99～119, 160±10)
(30±5, 82～98, 0±10)
(30±5, 28～53, 140±10)
(30±5, 70～103, 160±10)

17. The surface acoustic wave device according to Claim 16, wherein Euler angles of the piezoelectric substrate made of $LiNbO_3$ are in any of the ranges shown in the following Table 4.

[Table 4]

$k_R^2 \leq 0.049$
(0±5, 88～117, 0±10)
(0±5, 115～124, 0±10)
(0±5, 115～135, 80±10)
(0±5, 109～157, 100±10)
(10±5, 130～146, 80±10)
(10±5, 80～87, 100±10)
(10±5, 98～118, 160±10)
(20±5, 110～118, 160±10)
(30±5, 86～94, 0±10)
(30±5, 33～47, 140±10)
(30±5, 77～103, 160±10)

18. The surface acoustic wave device according to any one of Claims 1 to 14, wherein Euler angles of the piezoelectric substrate made of $LiNbO_3$ are in any of the ranges shown in the following Table 5.

[Table 5]

Euler angles
(0±5, 38±10, 0)
(0±5, 89±10, 77～102±5)
(0±5, 130±10, 79±5)
(10±5, 110±10, 50～80±5)
(10±5, 110±10, 106±5)
(20±5, 100±10, 35～72±5)
(20±5, 100±10, 100～110±5)
(30±5, 89±10, 40～80±5)
(30±5, 100±10, 40～117±5)

19. The surface acoustic wave device according to Claim 18, wherein Euler angles of the piezoelectric substrate made of $LiNbO_3$ are in any of the ranges shown in the following Table 6.

[Table 6]

Euler angles
(0±5, 38±10, 0)
(0±5, 89±10, 80～100±5)
(10±5, 110±10, 50～80±5)
(20±5, 100±10, 42～70±5)
(30±5, 89±10, 42～76±5)
(30±5, 100±10, 42～72±5)